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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	Paul A. Stucky
Serial No.:	10/598,044
Filed :	08/16/2006
Art Unit:	2837
Examiner:	Chan, Kawing
Confirmation No.:	9489
Title:	ELECTRICAL SIGNAL APPLICATION STRATEGIES FOR MONITORING A CONDITION OF AN ELEVATOR LOAD BEARING MEMBER

APPEAL BRIEF

Mail Stop Appeal Brief - Patents
Commissioner for Patents
P. O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

Appellant now submits its brief in this appeal for which the Notice of Appeal was filed on May 6, 2010. The Commissioner is authorized to charge the credit card in the name of U.S. Patent and Trademark Office, c/o Otis Elevator Company, in the amount of $540.00.

Real Party in Interest

Otis Elevator Company is the real party in interest. Otis Elevator Company is a business unit of United Technologies Corporation.

Related Appeals and Interferences

There are no related appeals or interferences.

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Status of the Claims

Claims 1-20 are pending and on appeal.

Claims 1, 2, 6-8, 13, 14, 16 and 20 stand rejected under 35 U.S.C. §103 as being unpatentable over WO 00/58706 (the *Robar* reference) in view of U.S. Patent No. 6,601,448 (the *Bernard* reference).

Claims 3, 9, 10, 15, 17 and 18 stand rejected under 35 U.S.C. §103 as being unpatentable over the *Robar* reference in view of the *Bernard* reference and further in view of U.S. Patent Application Publication No. 2002/0194935 (the *Clarke* reference).

Claims 4, 5, 11, 12 and 19 stand rejected under 35 U.S.C. §103 as being unpatentable over the *Robar* reference in view of the *Bernard* reference and further in view of U.S. Patent No. 5,338,417 (the *Brucken* reference).

Status of Amendments

An amendment is being filed concurrently with this Appeal Brief. That amendment is merely correcting minor clerical errors in some dependent claims to ensure the proper antecedent basis for all limitations in that claim. At this time, Appellant does not know whether the Examiner will enter that amendment but is confident that it should be entered as it does not raise any new issues.

Summary of Claimed Subject Matter

There are three independent claims on appeal and several dependent claims are argued separately. Each of those claims is reproduced below including references to the drawings and specification. The included references are for satisfying the rules regarding appeal briefs and do not necessarily limit the claims in any way. Rather, the references demonstrate how the claims read on an example embodiment.

1. A method of monitoring a condition of an elevator load bearing member (30, Fig. 2) that has a plurality of spaced, electrically conductive tension members (32, Fig. 2) {page 3, lines 22-29}, comprising the steps of:

applying a selected electric signal comprising a plurality of pulses and having a duty ratio that is less than about 10% to at least one of the tension members {page 7, lines 9-14}.

2. The method of claim 1, including applying the signal to one of the tension members at a time {page 4, lines 19-26}.

4. The method of claim 1, including establishing the tension member carrying the signal as a cathode relative to a hoistway where the belt assembly is used {page 7, lines 15-20}.

5. The method of claim 4, including controlling a potential of the electric signal such that the potential is negative compared to a ground potential of the hoistway {page 7, lines 15-20}.

6. The method of claim 1, wherein the electric signal is applied only to non-adjacent tension members at a time {page 4, line 30 – page 5, line 17}.

8. A device for monitoring a condition of an elevator load bearing member (30, Fig. 2) {page 3, lines 22-29} comprising:

a controller (42, Fig. 1, 3-7) that selectively applies an electric signal that comprises a plurality of pulses and has a duty ratio that is less than about 10% to at least one tension member (32, Fig. 2) {page 7, lines 9-14}.

11. The device of claim 8, wherein the controller applies the electric signal such that the tension member carrying the signal is a cathode relative to a hoistway where the belt assembly is used {page 7, lines 15-20}.

12. The device of claim 11, wherein the electric signal has a polarity that is negative compared to a ground potential of the hoistway {page 7, lines 15-20}.

13. The device of claim 8, wherein the electric signal is applied only to non-adjacent tension members at a time {page 4, line 30 – page 5, line 17}.

16. An elevator load bearing member assembly (30, Fig. 2), comprising:
a plurality of electrically conductive tension members (32, Fig. 2) {page 3, lines 22-29};
a nonconductive jacket (34, Fig. 2) generally surrounding the tension members {page 3, lines 22-26}; and
a controller (42, Fig. 1, 2-8) that selectively applies an electric signal comprising a plurality of pulses and a duty ratio that is less than about 10% to at least one of the tension members {page 7, lines 9-14}.

19. The assembly of claim 16, wherein the electric signal has a polarity that is negative compared to a ground potential of a hoistway where the assembly is used {page 7, lines 15-20}.

Grounds of Rejection to be Reviewed on Appeal

Claims 1, 2, 6-8, 13, 14, 16 and 20 stand rejected under 35 U.S.C. §103 as being unpatentable over WO 00/58706 (the *Robar* reference) in view of U.S. Patent No. 6,601,448 (the *Bernard* reference).

Claims 3, 9, 10, 15, 17 and 18 stand rejected under 35 U.S.C. §103 as being unpatentable over the *Robar* reference in view of the *Bernard* reference and further in view of U.S. Patent Application Publication No. 2002/0194935 (the *Clarke* reference).

Claims 4, 5, 11, 12 and 19 stand rejected under 35 U.S.C. §103 as being unpatentable over the *Robar* reference in view of the *Bernard* reference and further in view of U.S. Patent No. 5,338,417 (the *Brucken* reference).

ARGUMENT

There is no *prima facie* case of obviousness against any of Appellant's claims. There must be a legally sufficient reason for making a proposed combination in order for that combination to be proper. When there is no benefit provided by a proposed modification to a primary reference, the legally required reason for making that combination is missing and the combination cannot even be made. Additionally, where a proposed combination would remove an intended feature from a

reference or change its principle of operation, that combination cannot be made and there is no *prima facie* case of obviousness. In this case the Examiner's proposed modifications to the *Robar* reference do not provide any benefit, would eliminate an intended feature from the *Robar* reference, and its principle of operation. The proposed combinations cannot be made and there is no *prima facie* case of obviousness. Even if the proposed combination could be made, the result is not sufficient to establish a *prima facie* case of obviousness.

The rejection of claims 1, 2, 6-8, 13, 14, 16 and 20 under 35 U.S.C. §103 must be reversed.

The Examiner proposes to modify the *Robar* reference with teachings from the *Bernard* reference. That combination cannot be made for several reasons.

The *Robar* reference discloses a system 600 shown in Figure 9 where an elevator rope 602 is connected at ends 604 and 606 to a current input lead and output lead, respectively. A floating stable constant current source 612 is supplied at one end of the rope 602. Current is passed through the rope and the resistance of the rope is determined.

The Examiner proposes to modify the *Robar* reference because the Examiner properly recognizes that the *Robar* reference does not contain any teaching of using an electric signal comprising a plurality of pulses having a duty ratio that is less than about 10%. The Examiner attempts to find such a teaching in the *Bernard* reference.

The *Bernard* reference has nothing whatsoever to do with elevator systems or monitoring a load bearing member in an elevator system. Instead, the *Bernard* reference is concerned with a mass flow meter. A particular arrangement is shown in the *Bernard* reference for measuring the flow of kerosene. As discussed in column 1, lines 47-52; column 3, lines 32-39; and column 3, line 55 – column 4, line 2, the *Bernard* reference includes a heating resistive wire placed in the path of a fluid whose flow is to be measured. Heating current pulses are applied to the wire to heat up the

wire. Then a cooling speed is determined between the pulses. The cooling speed is used for deriving mass flow information. It is important to note that the determinations in the *Bernard* reference are made during each period separating two successive current pulses and the determinations are not intended to convey information regarding a condition of the wire but, rather, are for determining a flow rate of the fluid (e.g., kerosene). The determinations in the *Bernard* reference are determinations regarding a fluid that is separate from the wire that is heated. In other words, there is no concern regarding a condition of the wire in that reference and the determinations are not intended to be used for evaluating the wire, itself.

The *Bernard* technique has no applicability to the *Robar* reference. Using current pulses for determining a cooling speed of a wire to determine flow rate of a fluid has no applicability or usefulness within the context of the *Robar* reference. There is no benefit to taking the teachings of the *Bernard* reference and applying them to the *Robar* reference. What possible benefit would a flow rate determination provide in the context of the *Robar* reference? Without any benefit, the proposed combination cannot be made and there is no *prima facie* case of obviousness. The rejection must be reversed.

Further, there is no need for heating any of the portions of the rope 602 in the *Robar* reference. The pulses of the *Bernard* reference are used to heat the wire. It follows that the pulses of the wire heating technique of the *Bernard* reference do not provide any benefit within the context of the *Robar* reference. Therefore, the legally required reason for making the proposed combination is missing.

Moreover there would be a significant disadvantage to applying the teachings of the *Bernard* reference within the context of the *Robar* reference. In fact, heating up the steel cords in the *Robar* rope would cause significant problems because it would tend to soften or melt the jacket

covering those cords and interfere with the connection between the cords and the jacket material. Given that the proposed combination would render the rope of the *Robar* reference unsuitable for its intended purpose, the modification cannot be made. Another way of looking at this is that the *Bernard* reference actually teaches away from the proposed combination. Either way, this is yet another reason why the proposed combination cannot be made.

There are other reasons why the proposed combination cannot be made. The *Robar* reference specifically teaches a stable constant current source. The Examiner proposes to replace that with an intermittent current source by using pulses from the *Bernard* reference in place of *Robar's* constant current source. Such a change would eliminate the intended feature of a constant current source from the teachings of the *Robar* reference. Such a change cannot be made when attempting to manufacture a *prima facie* case of obviousness.

The Examiner suggests that the *Bernard* reference teaches constant current because each of the current pulses has the same magnitude. That only tells part of the story, however. Applying pulses according to the teachings of the *Bernard* reference necessarily means not applying the same current value at the time when the pulses are not applied. In fact, the *Bernard* reference actually teaches applying two different current values to the heating wire of that reference. As explained in the last paragraph of column 3, a very weak current flows in the wire that is significantly lower than the current value of the pulses during the time between successive pulses. Therefore, the *Bernard* reference does not teach a constant current application technique. Instead, it uses different currents at different times. Replacing *Robar's* constant current source with *Bernard's* pulse technique would remove the intended feature of a constant current source from the *Robar* reference and change its principle of operation from one in which a constant current is applied to one in which

Bernard's pulses and different current levels are applied. Such a modification to the *Robar* reference cannot be made.

Additionally, the *Bernard* reference does not teach using the current pulses for making any measurements. Instead, the *Bernard* reference teaches observing the cooling rate of the heating wire during the times between successive pulses to determine the flow rate of kerosene. If one were to substitute in *Bernard's* technique for that of the *Robar* reference, that would completely change the principle of operation. The *Robar* reference is intended to measure resistance when the current is being applied to the rope. The *Bernard* reference teaches an opposite technique in which cooling speed is measured during the times between the current pulses -- not when current pulses are applied. Therefore, this is another way in which the Examiner's proposed modification to the *Robar* reference would change its principle of operation and the combination cannot be made.

The Examiner cannot take pieces of the *Bernard* reference and extract them from the context of the reference for what it actually conveys to a person of skill in the art. When one considers what the teachings of the *Bernard* reference would actually say to a person of skill in the elevator art using the *Robar* technique, it is clear that there is no motivation or suggestion for making the proposed combination. Determining a flow rate of a fluid by heating a wire in the fluid and then assessing the cooling speed of the wire during times when the current pulses are not applied to the wire has nothing to offer to one skilled in the art who would be considering the teachings of the *Robar* reference. The *Robar* reference is concerned with a condition of an elevator rope while the *Bernard* reference is not concerned with a condition of the heating wire at all but, rather, is only concerned with a flow rate of the fluid within which the wire is immersed.

If one were to make the proposed combination, there would be no benefit, it would remove an intended feature from the *Robar* reference, it would be disadvantageous in the context of the

Robar reference and it would change the principle of operation in the *Robar* reference. Each one of these reasons is independently dispositive of the question whether there is a *prima facie* case of obviousness. Given that all of them indicate that the proposed combination cannot be made, there is no possible *prima facie* case of obviousness. The rejection must be reversed.

Additionally, even if the proposed combination could be made, there still is no result that is enough to establish a *prima facie* case of obviousness. There is no teaching regarding using a duty cycle less than about 10% in either reference. The *Bernard* reference says that it uses "well-determined current pulses." The *Bernard* reference refers back to EP 210509, a copy of which is included in the evidence appendix of this brief. That document shows a duty ratio of approximately 33% when one considers the duration of the pulses in Figure 2a compared to the duration of the times between the pulses. A duty ratio of about 30 or 33% does not in any way teach or suggest a duty ratio of less than 10%. It cannot be considered obvious to modify the duty ratio relied upon in the *Bernard* reference as suggested by the Examiner. The Examiner would have to provide some evidence that reducing the duty ratio from about 30 or 33% down to about 10% would not interfere with the ability of the *Bernard* reference to achieve its intended result. Given that the Examiner has no such evidence, it cannot be considered obvious to modify any duty ratio to achieve that which is recited in Appellant's claims without some further evidence explaining a reason for doing so or the legitimacy of doing so.

Even if the proposed combination could be made, the absence of the teaching of a duty ratio on the order of about 10% from the proposed combination renders the result of the proposed combination incapable of establishing a *prima facie* case of obviousness. The rejection must be reversed.

Claim 2 is separately patentable.

In addition to the reasons given above for why there is no *prima facie* case of obviousness, claim 2 is separately patentable because it recites "applying the signal to one of the tension members at time." There are a plurality of electrically conductive tension members within an elevator load bearing member according to claims 1 and 2. The Examiner alleges that such a teaching is found in Figure 9 of the *Robar* reference. The Examiner alleges that the element labeled 602 is one of the tension members. That is incorrect. The entire rope is labeled 602 in the *Robar* reference. Applying current to the entire rope is not the same thing as applying current to only one of the tension members within the rope at a time. Therefore, the limitations of claim 2 are not found in the *Robar* reference as alleged by the Examiner. Without that, even if the proposed combination could be made (which Appellant denies for the reasons given above) there is no *prima facie* case of obviousness against claim 2. At a minimum, the rejection of that claim must be reversed.

Claims 6 and 13 are separately patentable.

In addition to the reasons given above for why there is no *prima facie* case of obviousness, claims 6 and 13 recites that the electric signal is "applied only to non-adjacent tension members at a time." There is no teaching whatsoever within the *Robar* or *Bernard* references for this approach.

The Examiner refers to page 9, lines 24-28 of the *Robar* reference when attempting to allege a *prima facie* case of obviousness against claims 6 and 13. The Examiner is correct that *Robar* does not disclose applying a signal only to non-adjacent tension members at a given time. The Examiner suggests that it would be obvious to do so to "choose any two or more of the cords inside the rope to compare the result." (Page 7 of the Final Office Action) There is no basis for such an unguided and unmotivated leap into the dark.

The reason why non-adjacent tension members are used in claims 6 and 13 is to avoid a possible source of corrosion risk if a sufficient electric field were established between cords such that ions could migrate between the tension members. This is explained in Appellant's specification from page 4, line 30 through page 5, line 17. There is nothing in the *Robar* reference that recognizes this and certainly nothing in the *Bernard* reference, which does not have anything to do with corrosion risk or elevator tension members in the first place. Nothing in either reference would provide any basis to lead a person of skill in the art to the invention of claims 6 or 13. Each of these claims is separately patentable from their respective independent claims. At a minimum, the rejection of claim 6 and the rejection of claim 13 must be reversed.

The rejection of claims 3, 9, 10, 15, 17 and 18 under 35 U.S.C. §103 must be reversed.

The Examiner again relies upon the improper combination of the *Robar* and *Bernard* references. Those references cannot be combined for any of the reasons given above. The Examiner proposes to add teachings form the *Clarke* reference for purposes of rejecting claims 3, 9, 10, 15, 17 and 18. The proposed addition of teachings from the *Clarke* reference does nothing to remedy the defects in the proposed base combination of the *Robar* and *Bernard* references. The combination cannot be made and there is no *prima facie* case of obviousness. The rejection must be reversed.

The rejection of claims 4, 5, 11, 12 and 19 under 35 U.S.C. §103 must be reversed.

The Examiner proposes to combine the *Robar* and *Bernard* references with the *Brucken* reference. As explained above, the base combination of the *Robar* and *Bernard* references cannot be made. Additionally, the *Brucken* reference cannot be added for many of the same reasons.

The *Brucken* reference has nothing to do with elevator systems or determining a condition of a tension member within an elevator load bearing assembly. Instead, the *Brucken* reference is concerned with cathodic corrosion protection for a surface of a metallic, aluminum-containing substrate that can be flushed by an electrolyte. That has nothing whatsoever to do with the elevator art. One skilled in the art looking at the *Robar* reference would not consider the *Brucken* reference for any reason.

The Examiner proposes to extract teachings from the *Brucken* reference, which have nothing to do with elevator systems or elevator load bearing members, and to somehow incorporate that into the arrangement of the *Robar* reference, which is concerned with monitoring the condition of an elevator load bearing member. There would be no reason to look to the teachings of the *Brucken* reference for how to allegedly modify the *Robar* reference. Therefore, the proposed combination cannot be made.

The issues presented in the *Brucken* reference have to do with aluminum oxide on an aluminum-containing substrate that faces an electrolyte. There are electrochemical conditions at such a surface of a substrate that can result in the formation of excessive alkaline boundary layers. (Column 2, lines 54-61 of the *Brucken* reference). Given that such a scenario does not possibly exist in the *Robar* reference, there is no reason whatsoever to consult the teachings of the *Brucken* reference for determining how to modify the improper combination of the *Robar* and *Bernard* references. The proposed combination cannot be made.

Further, even if the proposed combination could be made, there is nothing within the proposed combination that teaches the limitations of claims 4 and 11 each of which has an electric signal applied to the tension member carrying the signal so that the tension member is a cathode

relative to a hoistway where the belt assembly is used.[1] Even if one were to apply the cathodic approach of the *Brucken* reference, there still is no teaching for establishing a tension member as a cathode relative to a hoistway. Instead, the *Brucken* reference teaches that a surface of a substrate could serve as a cathode. That cathode is a cathode relative to a counter-electrode that is provided as an anode. There simply is no teaching within the proposed combination of three references that leads to the result of either of claims 4 or 8. Therefore, there is no *prima facie* case of obviousness against either of those claims.

Claims 5, 12 and 19 are separately patentable.

Each of claims 5, 12 and 19 include a potential of the electric signal that is negative compared to a ground potential of a hoistway in which the elevator load bearing member is used. There is no such teaching of that within the *Brucken* reference or the proposed combination of the *Robar, Bernard* and *Brucken* references. Therefore, even if the proposed combination could be made, which Appellant denies, there is no *prima facie* case of obviousness and the rejection of claims 5, 12 and 19 must be reversed.

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[1]Appellant is separately attempting to amend claim 4 to replace "belt assembly" with "elevator load bearing member" to ensure proper antecedent basis in claim 4. The same is true of claim 11.

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CONCLUSION

There is no *prima facie* case of obviousness against any one of Appellant's claims. The Examiner's proposed combination of references cannot be made. Even if the combinations could be made, the result does not establish a *prima facie* case of obviousness. All rejections under 35 U.S.C. §103 must be reversed.

Respectfully submitted,

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26 July 2010

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CERTIFICATE OF FACSIMILE

I hereby certify that this Appeal Brief regarding the appeal for Application Serial No. 10/598,044 is being facsimile transmitted to the Patent and Trademark Office, (Fax No. (571) 273-8300) on July 26, 2010.

David Gaskey

CLAIMS APPENDIX

1. A method of monitoring a condition of an elevator load bearing member that has a plurality of spaced, electrically conductive tension members, comprising the steps of:

applying a selected electric signal comprising a plurality of pulses and having a duty ratio that is less than about 10% to at least one of the tension members.

2. The method of claim 1, including applying the signal to one of the tension members at a time.

3. The method of claim 1, including coupling at least two non-adjacent tension members in an electrically conductive manner and applying the electric signal to the coupled tension members.

4. The method of claim 1, including establishing the tension member carrying the signal as a cathode relative to a hoistway where the belt assembly is used.

5. The method of claim 4, including controlling a potential of the electric signal such that the potential is negative compared to a ground potential of the hoistway.

6. The method of claim 1, wherein the electric signal is applied only to non-adjacent tension members at a time.

7. The method of claim 1, including determining a resistance of the tension members based upon the applied signal.

8. A device for monitoring a condition of an elevator load bearing member comprising:

a controller that selectively applies an electric signal that comprises a plurality of pulses and has a duty ratio that is less than about 10% to at least one tension member.

9. The device of claim 8, including a connector that establishes an electrically conductive connection between the controller and the tension member.

10. The device of claim 9, wherein the connector includes at least one coupling that couples at least two non-adjacent tension members together.

11. The device of claim 8, wherein the controller applies the electric signal such that the tension member carrying the signal is a cathode relative to a hoistway where the belt assembly is used.

12. The device of claim 11, wherein the electric signal has a polarity that is negative compared to a ground potential of the hoistway.

13. The device of claim 8, wherein the electric signal is applied only to non-adjacent tension members at a time.

14. The device of claim 8, wherein the controller determines a resistance of the tension members and determines a condition of the load bearing member based upon the determined resistance.

15. The device of claim 8, wherein the controller applies the signal to an entire plurality of tension members simultaneously.

16. An elevator load bearing member assembly, comprising:

a plurality of electrically conductive tension members;

a nonconductive jacket generally surrounding the tension members; and

a controller that selectively applies an electric signal comprising a plurality of pulses and a duty ratio that is less than about 10% to at least one of the tension members.

17. The assembly of claim 16, including a connector that establishes an electrically conductive connection between the controller and the tension members.

18. The assembly of claim 17, wherein the connector includes at least one coupling that couples at least two non-adjacent tension members together.

19. The assembly of claim 16, wherein the electric signal has a polarity that is negative compared to a ground potential of a hoistway where the assembly is used.

20. The assembly of claim 16, wherein the duty cycle is less than about 1%.

RELATED PROCEEDINGS APPENDIX

None.

EVIDENCE APPENDIX

EP 210509 (a copy of this document is attached on the following pages)

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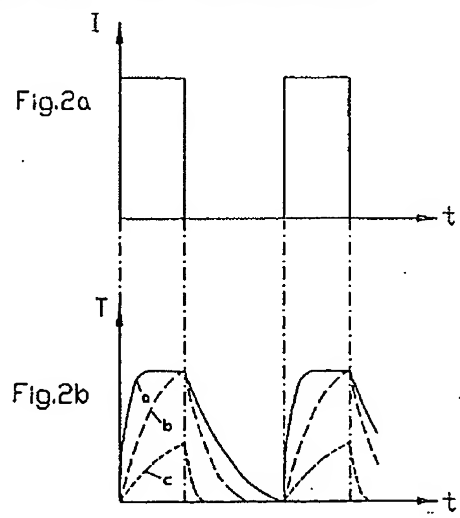
(54) **Verfahren zum Messen der Eigenschaften eines Fluids sowie Sensorelement zur Durchführung des Verfahrens.**

(57) Zur Messung der Eigenschaften eines Fluids ist ein Verfahren beschrieben, bei welchem ein Sensorelement mit temperaturabhängigem elektrischen Widerstand mit dem Fluid in Wärmekontakt steht. Das Sensorelement, z. B. ein Halbleiter, ist während eines ersten, vorbestimmten und begrenzten Zeitintervalls stromdurchflossen und wird mit vorbestimmter elektrischer Leistung aufgeheizt. Während eines anschließenden vorbestimmten und begrenzten Zeitintervalles wird das Sensorelement gekühlt. Aus der Widerstandsänderung des Sensorelementes, welche dem Temperaturverlauf des Elementes während der Heizphase bzw. der Kühlphase entspricht, kann unmittelbar auf die Eigenschaften des Fluids, z. B. die Art, Zusammensetzung, Strömungsgeschwindigkeit bzw. Massenstrom oder auch das Niveau eines in einem Behälter befindlichen Fluids rückgeschlossen werden.



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Verfahren zum Messen der Eigenschaften eines Fluids sowie Sensorelement zur Durchführung des Verfahrens

Die Erfindung betrifft ein Verfahren zum Messen der Eigenschaften eines Fluids sowie ein zur Durchführung des Verfahrens geeignetes Sensorelement.

Unter Eigenschaften des Fluids seien insbesondere die Art bzw. Zusammensetzung des Fluids, die Strömungsgeschwindigkeit bzw. der Massenstrom eines strömenden Fluids oder das Niveau eines in einem Behälter befindlichen Fluids verstanden.

Es sind Verfahren bekannt, bei welchen aus der Widerstandsänderung eines von elektrischem Strom durchflossenen Sensorelementes mit temperaturabhängigem Widerstand auf die Fluideigenschaft rückgeschlossen wird. Es ist auch bekannt, als Sensorelement einen Halbleiter zu verwenden.

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Aus der DE-PS 813 968 ist beispielsweise eine derartige Anordnung zur Messung des Flüssigkeitsstandes bekannt, bei welcher ein Widerstandskörper mit großem, insbesondere negativem Temperaturkoeffizienten in wärmeaustauschender Berührung mit der Flüssigkeit steht. Bei Austauchen des Widerstandskörpers aus der Flüssigkeit erfolgt eine Änderung der Wärmeabfuhr, die eine Widerstandsänderung zur Folge hat. Diese Widerstandsänderung kann zur Erzeugung eines Steuersignales, z. B. eines Warnsignales, ausgenutzt werden.

Eine derartige Anordnung ist ungeeignet für quantitative Messungen sowie für dynamische Betriebsweise, also bei sich während der Messung ändernden Fluideigenschaften, insbesondere sich ändernder Temperatur.

Der vorliegenden Erfindung liegt die Aufgabe zugrunde, ein Verfahren auf der im Oberbegriff des Hauptanspruchs angegebenen Basis zu schaffen, mit welchem die Fluideigenschaften quantitativ gemessen werden können und das auch für dynamischen Betrieb geeignet ist.

Gelöst wird diese Aufgabe mit dem gemäß Anspruch 1 gekennzeichneten Verfahren.

Charakteristisch für dieses Verfahren ist, daß das Sensorelement derart bestromt ist, daß es abwechselnd geheizt und gekühlt und aus dem Verlauf der Heizkurve bzw. Abkühlungskurve Meßwerte hergeleitet werden, welche für die eingangs angegebenen Fluideigenschaften

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charakteristisch sind.

Zur Ermittlung der Aufheizgeschwindigkeit bzw. des Verlaufes der Heizkurve kann folglich die Widerstandsänderung des Sensorelementes schon während der Aufheizphase gemessen werden. Ebenso kann zur Ermittlung der Abkühlgeschwindigkeit, also der Abkühlungskurve, die Widerstandsänderung des Sensorelementes während der Kühlphase gemessen werden.

Nach einem einfach realisierbaren Vorschlag wird zur Ermittlung der Widerstandsänderung die Differenz der Widerstandswerte des Sensorelementes jeweils am Anfang und am Ende der Heiz- bzw. Kühlphase gemessen.

Vorteilhafter ist es, wie nach einem weiteren Vorschlag angegeben, zur Ermittlung der Widerstandsänderung die Steigung der Widerstandskurve in Abhängigkeit von der Zeit in einem vorgegebenen Zeitpunkt zu messen. Bei dieser Verfahrensweise beeinflußt die absolute Temperatur des zu untersuchenden Fluids nicht den Meßwert.

Zweckmäßig für Messung und Auswertung der Meßergebnisse ist, wenn das Zeitintervall der Heizphase und/oder Kühlphase mindestens so lang ist, daß sich Sensorelement und Fluid in einem stationären thermischen Gleichgewicht befinden.

Um die möglicherweise wechselnden Eigenschaften eines Fluids kontinuierlich zu erfassen, sollten sich einem weiteren Vorschlag der Erfindung Heizphasen- und Kühlphasenintervalle periodisch

wiederholen.

Von den bekannten Verfahren unterscheidet sich das erfindungsgemäße vor allem dadurch, daß das Sensorelement abwechselnd aufgeheizt und gekühlt wird und selbst vorzugsweise während der Kühlphase als Meßelement geschaltet ist. Bei dieser Verfahrensweise wird das Element, das eine vorbestimmte Wärmekapazität aufweist, auf eine vorbestimmte Temperatur aufgeheizt, worauf anschließend nach Beendigung des Aufheizvorganges aus dem Verlauf der Abkühlungskurve für das Fluid charakteristische Daten hergeleitet werden.

Der Verlauf dieser Abkühlungskurve ist hierbei wesentlich durch Art und Zustand des Fluids bestimmt.

Bei stehendem Fluid kann das Fluidniveau, also z. B. die Füllstandshöhe in einem Behälter, gemessen oder überwacht werden.

Bei einem Massenstrom kann bei wechselnder Strömungsgeschwindigkeit diese Strömungsgeschwindigkeit laufend erfaßt werden.

Bei gleichbleibender Strömung kann dagegen die Fluidart bestimmt werden, da für jede Fluidart eine bestimmte Abkühlungskurve charakterisch ist.

Darüber hinaus ist es bei Kenntnis der Abkühlungskurven bestimmter Fluidarten möglich, aus diesen auf die Zu-

sammensetzung eines Fluidgemisches rückzuschließen.

In entsprechender Weise kann anhand der Abkühlungskurve auf etwaige Verschmutzungen und damit den Verschmutzungsgrad eines Fluids rückgeschlossen werden.

Als Sensorelement eignet sich vorzugsweise ein aus Halbleitermaterial bestehendes, vom elektrischen Strom aufheizbares Element mit wenigstens einem für Temperaturmessung geeigneten pn-Übergang. Damit ist mit demselben Element Aufheizen und Messen möglich. Die Verwendung von Halbleitermaterial hat den besonderen Vorteil, daß Sensorelemente kleinster Abmessungen auf einfache und kostengünstige Art hergestellt werden können, wobei Temperaturen bis zu 300°C ohne Glüheffekte oder dergl. erreicht werden können. Sensorelemente dieser Art können folglich unter schwierigen Verhältnissen zuverlässig eingesetzt werden.

Dieses Halbleiterelement kann, wie ferner vorgeschlagen ist, als Sperrschicht- oder MOS-Feldeffekttransistor ausgebildet sein.

Nach einem weiteren Vorschlag der Erfindung ist es ratsam, dieses Sensorelement in einem wärmeleitenden, jedoch fluiddichten Gehäuse zu kapseln.

Das erfindungsgemäße Verfahren ist nachfolgend anhand schematischer in der Zeichnung wiedergegebener Darstel-

lungen näher erläutert. In diesen Zeichnungen zeigen

Figur 1 - schematische Darstellung eines erfindungsgemäßen Sensorelementes, das als Meßsonde in einer fluiddurchströmten Leitung angeordnet ist,

Figur 2a - Diagramm des der Aufheizung des Sensorelementes dienenden Stromes I in Abhängigkeit von der Zeit t.

Figur 2b - Temperatur T des Sensorelementes in Abhängigkeit von der Zeit t, bei Bestromung mit Stromimpulsen gemäß Figur 2a.

Als Sensorelement zur Durchführung des erfindungsgemäßen Verfahrens eignet sich grundsätzlich jeder elektrische Leiter, der durch Stromwärme aufheizbar ist und dessen elektrischer Widerstand von der Temperatur abhängig ist, so daß seine Widerstandsänderung ein Maß für die Temperaturänderung ist.

Vorzugsweise eignet sich als Sensorelement ein aus Halbleitermaterial bestehendes Element, das stromdurchflossen ist. Als Halbleiterelement kann eine einfache Diode mit pn-Übergang oder auch nur eine einfache Halbleiterstrecke Verwendung finden. Dieses Halbleiterelement ist während der Heizphase zu bestromen, während es zur Messung der Temperaturänderung in eine geeignete Meßschaltung zu schalten ist. Zweckmäßigerweise findet

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als Heizelement ein stromdurchflossenes Halbleiterelement Verwendung, das mit einer Steuerstrecke kombiniert ist. Bevorzugt ist hierbei ein Sperrschichtfeldeffekttransistor.

In Figur 1 ist schematisch ein Anwendungsfall gezeigt. Mit 10 sei ein Ausschnitt einer von einem Fluid durchströmten Rohrleitung gezeigt. Im Inneren 11 dieser Rohrleitung 10 ist ein Sensorelement nach der Erfindung so angeordnet, daß es von dem in Richtung der Pfeile 12 strömenden Fluid umströmt ist. Zweckmäßigerweise ist das Sensorelement 13 wärmeleitend jedoch fluiddicht gekapselt.

Zu Meßzwecken werden diesem Sensorelement 13 über die Leitungen 14 Stromimpulse in einem vorbestimmten und begrenzten Zeitintervall zugeleitet, wie dies mit dem Diagramm gemäß Figur 2a veranschaulicht ist. Die Zeitintervalle sind so bemessen, daß das Sensorelement, wie mit Figur 2b veranschaulicht ist, auf eine vorbestimmte Temperatur aufheizbar ist Kurven a, b in Fig. 2 b. Mittels eines über die Gate-Leitung 15 eingespeisten Steuerstromes kann die Heizleistung und damit die Endtemperatur eingestellt werden. Nach Beendigung des Heizintervalles, also zwischen zwei Stromimpulsen, während der sogenannten Kühlphase, kühlt das Sensorelement 13, das eine bestimmte Wärmekapazität hat, ab. Der Verlauf der aus Figur 2b während der Kühlphase ersichtlichen Abkühlungskurve hängt von Eigenschaften des Fluids, insbesondere der Fluidart und der Strömungsgeschwindigkeit, weitgehend ab. Diese Abkühlungskurve kann durch Messung der Widerstandsänderung

des Sensorelementes während der Kühlphase gemessen und zur Anzeige bzw. Aufzeichnung gebracht werden. Zu diesem Zweck ist an die Leitungen 14 und 15 eine geeignete Meßschaltung anzuschließen.

Aus dem Verlauf der Abkühlungskurve kann auf Strömungsgeschwindigkeit und damit auf den die Leitung durchfließenden Massenstrom rückgeschlossen werden. Folglich eignet sich eine derartige Anordnung entweder zur Bestimmung der Strömungsgeschwindigkeit oder auch zur Bestimmung des Fluidverbrauches.

Bei konstanter Strömungsgeschwindigkeit in der Leitung 10 kann durch Analyse der Abkühlungskurven auf Art bzw. Zusammensetzung des Fluids in gleicher Weise geschlossen werden, da jede Fluidart eine spezifische Wärmeleitfähigkeit besitzt, die bei vorbestimmter Strömungsgeschwindigkeit zu einer vorbestimmten Abkühlungskurve, die mit dem Sensorelement 13 ermittelbar ist, führt.

Handelt es sich hierbei um ein Fluidgemisch mit vorbestimmter Strömungsgeschwindigkeit und sind die spezifischen Wärmeleitfähigkeiten der Fluidbestandteile bekannt, so läßt sich mit Hilfe dieser Messung auch die Zusammensetzung oder das Mischungsverhältnis des Fluidgemisches bestimmen.

Schließlich ist es mit der gleichen Methode möglich, die Verschmutzung des Fluids, z. B. bei hydraulischen Kreisen, durch Fremdstoffe festzustellen. Die in Figur 2b mit b und c bezeichneten Kurven veranschaulichen die unterschiedlichen Endtemperaturen bei Fluids mit unterschiedlichen Mischungsverhältnissen.

Die Auswerteelektronik kann sowohl mit dem Halbleiterplättchen des Sensorelementes integriert als auch, was bei höheren Temperaturen möglicherweise ratsam ist, getrennt vorgesehen sein.

Die Bestimmung der Temperaturänderung während der Kühlphase, als die Messung der Abkühlgeschwindigkeit, reicht in vielen Anwendungsfällen, insbesondere bei statischen Verhältnissen. Es kann aber auch von Vorteil sein, stattdessen die Aufheizkurve der Meßsonde zu erfassen. Wie mit den Kurven a, b und c in Figur 2b während der Heizphase veranschaulicht ist, hängt deren Verlauf auch genauso wie der Verlauf der Abkühlkurve von den Eigenschaften des Fluids ab.

Eine Auswertung dieser Kurven kann unter dynamischen Verhältnissen besonders nützlich sein. Hierbei ist ein

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periodisch intermittierender Betrieb, bei welchem das Sensorelement während der Heizphase aufgeheizt wird und während der Kühlphase als Meßelement dient, besonders vorteilhaft.

Bei Anordnung mehrerer, nahezu punktförmig ausbildbarer Sensorelemente der erfindungsgemäßen Art nach einem vorbestimmten Muster lassen sich Unterschiede in einem strömenden Medium, z. B. Strömungsunterschiede wie Übergänge laminarer Strömung in Turbulenz oder Abreiß-strömungen, gut erfassen.

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PATENTANSPRÜCHE

1. Verfahren zum Messen der Eigenschaften eines Fluids, insbesondere der Art, der Zusammensetzung, der Strömungsgeschwindigkeit bzw. des Massenstromes oder des Niveaus eines Fluids unter Verwendung eines mit dem Fluid in Wärmekontakt stehenden, von elektrischem Strom durchflossenen Sensorelementes mit temperaturabhängigem elektrischem Widerstand, dadurch gekennzeichnet, daß das Sensorelement während eines ersten vorbestimmten und begrenzten Zeitintervalls, der Heizphase, mit vorbestimmter elektrischer Leistung aufgeheizt, daß das Sensorelement während eines sich anschließenden, vorbestimmten und begrenzten Zeitintervalls, der Kühlphase, abgekühlt wird und daß die Widerstandsänderung des Sensorelementes mindestens während einer der beiden Phasen gemessen wird.

2. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß zur Ermittlung der Aufheizgeschwindigkeit die Widerstandsänderung des Sensorelementes während der Heizphase gemessen wird.

3. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß zur Ermittlung der Abkühlgeschwindigkeit die Widerstandsänderung des Sensorelementes während der Kühlphase gemessen wird.

4. Verfahren nach Anspruch 1, 2 oder 3, dadurch gekennzeichnet, daß das Zeitintervall der Heizphase und/oder Kühlphase mindestens so lang ist, daß sich Sensorelement und Fluid in einem stationären thermischen Gleichgewicht befinden.

5. Verfahren nach nur einem der Ansprüche 1 bis 4, dadurch gekennzeichnet, daß sich Heizphasen - und Kühlphaseninterval periodisch wiederholen.

6. Verfahren nach einem der Ansprüche 1 bis 5, dadurch gekennzeichnet, daß zur Ermittlung der Widerstandsänderung die Steigung der Widerstandskurve in Abhängigkeit von der Zeit in einem vorgegebenen Zeitpunkt gemesssen wird.

7. Verfahren nach einem der Ansprüche 1 bis 5, dadurch gekennzeichnet, daß zur Ermittlung der Widerstandsänderung die Differenz der Widerstandswerte des Sensorelementes am Anfang und Ende der Heiz- bzw. Kühlphase gemessen wird.

8. Sensorelement zur Durchführung des Verfahrens nach einem der Ansprüche 1 bis 7, dadurch gekennzeichnet, daß es aus durch elektrischen Strom aufheizbaren Halbleitermaterial besteht und wenigstens einen für Temperaturmessung geeigneten pn-Übergang aufweist.

9. Sensorelement nach Anspruch 8, dadurch gekennzeichnet, daß es als Sperrschicht - oder MOS-Feldeffekttransistor ausgebildet ist.

10. Sensor nach Anspruch 8 oder 9, gekennzeichnet durch die Anordnung in einem wärmeleitenden, jedoch fluiddichten Gehäuse.

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Fig.1

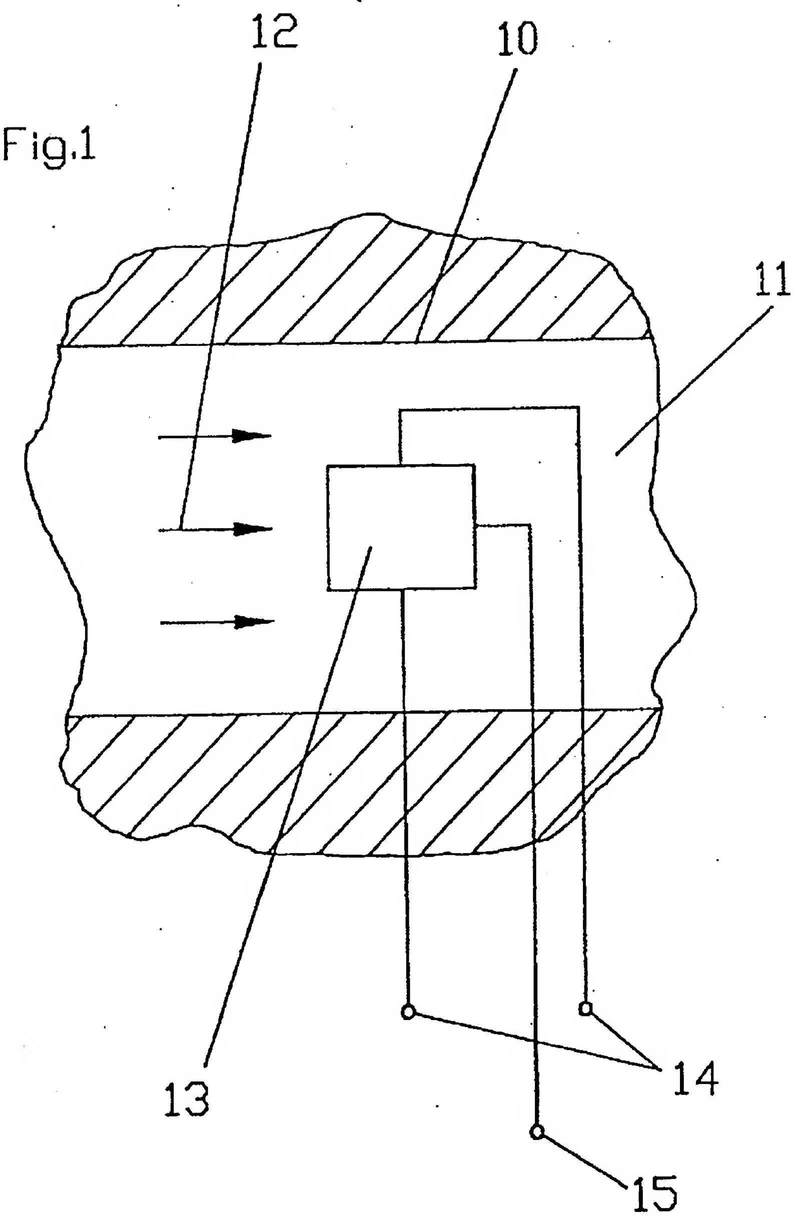

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Fig.2a

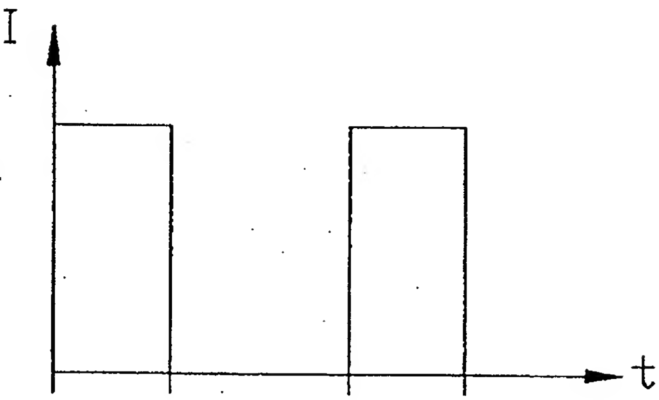

Fig.2b